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(54) Drilling apparatus.

(57) Drilling apparatus comprises a hollow drill pipe (2) extending through a drill hole (4) to a mud motor (8). The motor (8) drives a compressor (12) through a shaft (14). An annular passageway (16) around the compressor (12) leads to a drill bit (18) having nozzles (20) providing an outlet from the passageway (16). A housing (22) of the compressor (12) provides a passageway (24) for leading fluid through the compressor (12) to emerge through nozzles (26) in the drill bit (18) at increased pressure to assist the drill bit (18).

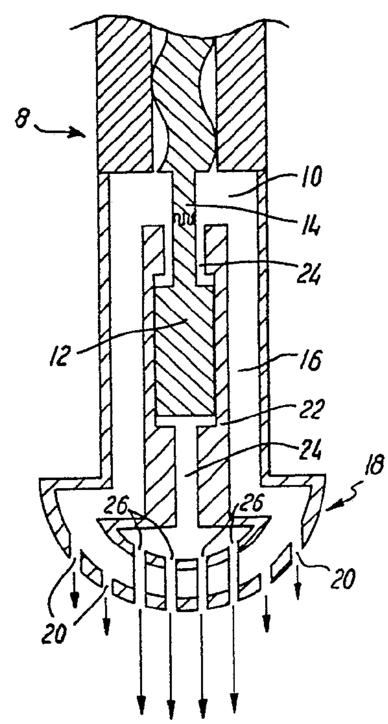

FIG.2

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Drilling Apparatus

This invention relates to drilling apparatus.

In conventional drilling, for example in the oil and gas industries, the drill bit is rotated by driving the entire drill string from the surface while drilling mud is circulated from the surface to the bit, where it collects cuttings, and thence back to the surface for removal of the cuttings. It has been proposed to provide jet assistance for the drilling action of the bit by conveying mud to the bottom of the drill hole through a dual-conduit drill string; one conduit conveys low-pressure high-volume mud to carry away the cuttings while the other conveys high-pressure low-volume mud to blast the formation ahead of the bit. Such a system requires substantial investment in specialised surface equipment and drill pipe.

According to the present invention there is provided drilling apparatus comprising a conduit for conveying drilling mud and having an outlet downhole, flow splitting means for dividing the drilling mud issuing from the outlet of the conduit into a first flow and a second flow, a downhole compressor having an inlet for receiving said first flow and increasing its pressure, a drill bit, an outlet from said flow splitting means for directing said second flow past the drill bit, and an outlet from said compressor for directing the compressed first flow past the drill bit.

The compressor increases the pressure of the first flow to transform it into a high-pressure low-volume flow which is directed against the formation to assist in its disintegration. The second flow acts as low-pressure high-volume to carry away the cuttings and disintegrated formation.

The flow splitting means may be provided by the size and form of the compressor's inlet which allows only a proportion of the incident flow to pass into the compressor. Alternatively a further item of apparatus may be provided designed specifically to create the desired flow split.

Preferably the second flow is directed along an annular passageway with the compressor disposed in the centre of the annulus.

The compressed first flow and/or the second flow may be directed through the drill bit, and preferably the compressed first flow issues beyond the drill bit with the second flow surrounding it.

The compressor is preferably driven by a downhole motor, for example a motor powered by the passage of the drilling mud; the motor may be disposed above the compressor so as to be driven by the drilling mud prior to splitting of the flow.

The compressed first flow preferably emerges through one or more nozzles which may be varied in direction.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawing in which:

Fig. 1 is a schematic side elevation of drilling apparatus of this invention; and

Fig. 2 is a schematic sectional side elevation of a lower portion of the apparatus of Fig. 1; and

Fig. 3 is an exploded schematic perspective view of a compressor of the drilling apparatus.

Referring to the drawings, Fig. 1 shows a hollow drill pipe 2 extending from the surface downwardly through a drill hole 4 and connecting through drill collars 6 with a mud motor 8 which may be positive displacement, turbine, membrane or vane type. Below the motor 8 is a chamber 10 which houses centrally a compressor 12 driven through a shaft 14 by the motor 8. The chamber wall and a housing 22 of the compressor 12 define between them an annular passageway 16 leading to a drill bit 18 having nozzles 20 providing an outlet from the passageway 16.

The housing 22 provides a passageway 24 for leading fluid through the compressor 12, the passageway 24 emerging through the nozzles 26 in the drill bit 18.

In use, the drill string comprising the drill pipe 2, drill collars 6, mud motor 8, compressor 12 and drill bit 18 are rotated from the surface and drilling mud is pumped as a normal low-pressure high-volume flow down through the drill string. The mud drives the motor 8 which in turn drives the compressor 12.

Drilling mud emerging from the motor into the chamber 10 is split into a first flow entering the passageway 24 and a second flow entering the annular passageway 16. The first flow is led through the compressor 12 where its volume is reduced and its pressure increased, and it then emerges as a high-pressure low-volume flow through the nozzles 26 in the drill bit 18, blasting against the formation ahead of the drill bit to assist in the formation's disintegration.

An example of a suitable membrane type compressor is illustrated in Fig. 3. The compressor 12 comprises a cylindrical membrane 28 of compressive material which defines a plurality of compression chambers 30. The cylindrical membrane 28 is mounted on a camshaft 32 which has an eccentric mid-section 34 with drive splines 36 at each end. End plates 38 are provided for the cylindrical membrane 28 and input and output timing discs 40 and 42 engage the splines 36 and abut the end plates 38.

The operation of this compressor will now be described. Drilling mud enters a compression

chamber 30 via a port 44 in the input timing disc 40. As this timing disc 40 is splined to the camshaft 32 it rotates with the camshaft thus sealing the compression chamber 30. At the output end the output timing disc 42 is similarly splined to the camshaft 32. As the camshaft 32 rotates driven by the downhole mud motor 8, the eccentric mid-section 34 deforms the compression chamber 30 intensifying the pressure of the drilling mud within. This high pressure drilling mud then exits via a port 46 in the output timing disc 42 at the base of the compressor 12 to be forced through the nozzles 26.

As the camshaft 32 continues to rotate, each compression chamber 30 in turn experiences the same cycle of events resulting in a pulsed high pressure flow from the output end of the compressor. As a modification the timing discs could be replaced by a series of non return valves.

The second flow travels along the passageway 16 and emerges through the nozzles 20 as a low-pressure high-volume flow around the high-pressure low-volume flow from the nozzles 26. This second flow acts in the conventional manner of drilling mud by cooling the bit 18 and carrying cuttings away from the bit 18.

The mud of both flows then returns to the surface along the annular flow path defined between the wall of the drill hole 4 and the drill string. At the surface the cuttings are removed and the mud is then recirculated through the drill string.

The apparatus of this embodiment of the invention provides an <u>in situ</u> generated high-pressure flow of mud which "slots" the formation immediately ahead of the bit, thereby reducing or eliminating mechanical work required of the bit to increase the penetration rate while reducing or eliminating the wear on the bit.

For directional drilling applications, the bank of high-pressure nozzles can be positioned in the bit in such a way as to produce in the axis of the high-pressure mud flow a slight angular offset from the longitudinal axis of the bit. Thus whenever either a hole inclination or hole azimuth correction is required, drill string rotation is stopped with the high-pressure nozzles orientated in the appropriate direction. Hydrodynamic drilling then proceeds until the necessary correction had been completed. Subsequently rotation of the drill string recommences and hydrodynamically assisted drilling resumes. This procedure equates to the tactical application of conventional directional drilling jetting techniques currently in use in soft formation intervals, but also allows its application to formations currently considered too hard for the technique to be successful.

Modifications and improvements may be made without departing from the scope of the invention.

Claims

1. Drilling apparatus comprising a conduit for conveying drilling mud and having an outlet downhole, flow splitting means for dividing the drilling mud issuing from the outlet of the conduit into a first flow and a second flow, a downhole compressor having an outlet for receiving said first flow and increasing its pressure, a drill bit, an outlet from said flow splitting means for directing said second flow past the drill bit, and an outlet from said compressor for directing the compressed first flow past the drill bit.

2. Drilling apparatus as claimed in Claim 1, wherein the flow splitting means is provided by the size and form of the compressor's inlet.

3. Drilling apparatus as claimed in Claim 1 or 2, wherein the second flow is directed along an annular passageway with the compressor disposed in the centre of the annulus.

4. Drilling apparatus as claimed in Claim 1, 2 or 3, wherein the compressor first flow is directed through the drill bit and issues beyond the drill bit.

5. Drilling apparatus as claimed in any one of the preceding Claims, wherein the compressor is driven by a downhole motor.

6. Drilling apparatus as claimed in Claim 5, wherein the downhole motor is powered by the passage of the drilling mud.

7. Drilling apparatus as claimed in Claim 5 or 6, wherein the motor is disposed above the compressor.

8. Drilling apparatus as claimed in any one of the preceding Claims, whereby the compressor is a membrane type compressor.

9. Drilling apparatus as claimed in any one of the preceding Claims, wherein the compressed first flow emerges through one or more nozzles which may be varied in direction.

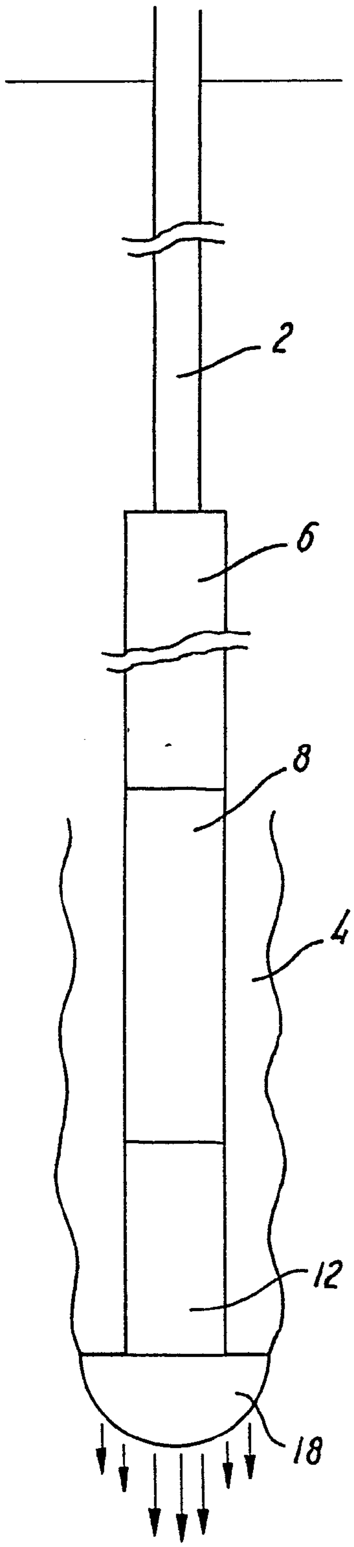

FIG. 1

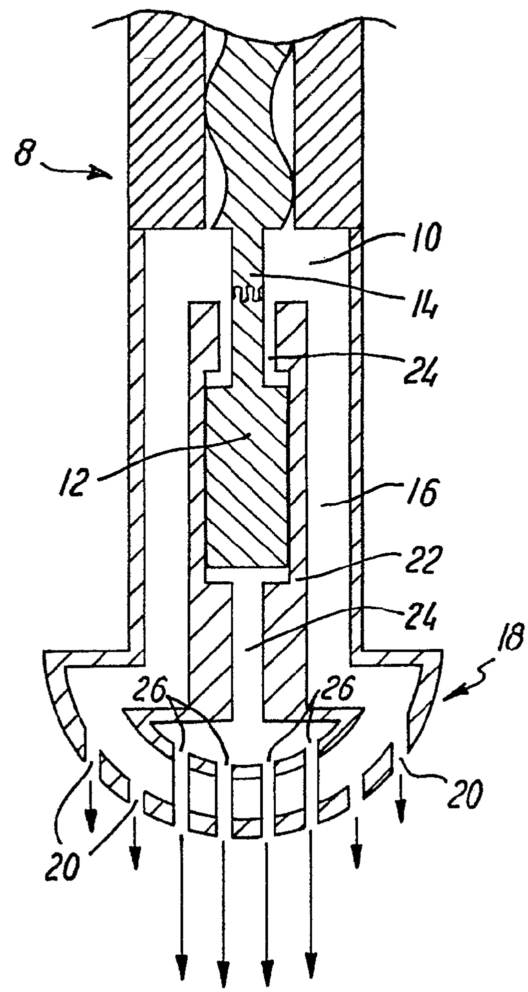

FIG. 2

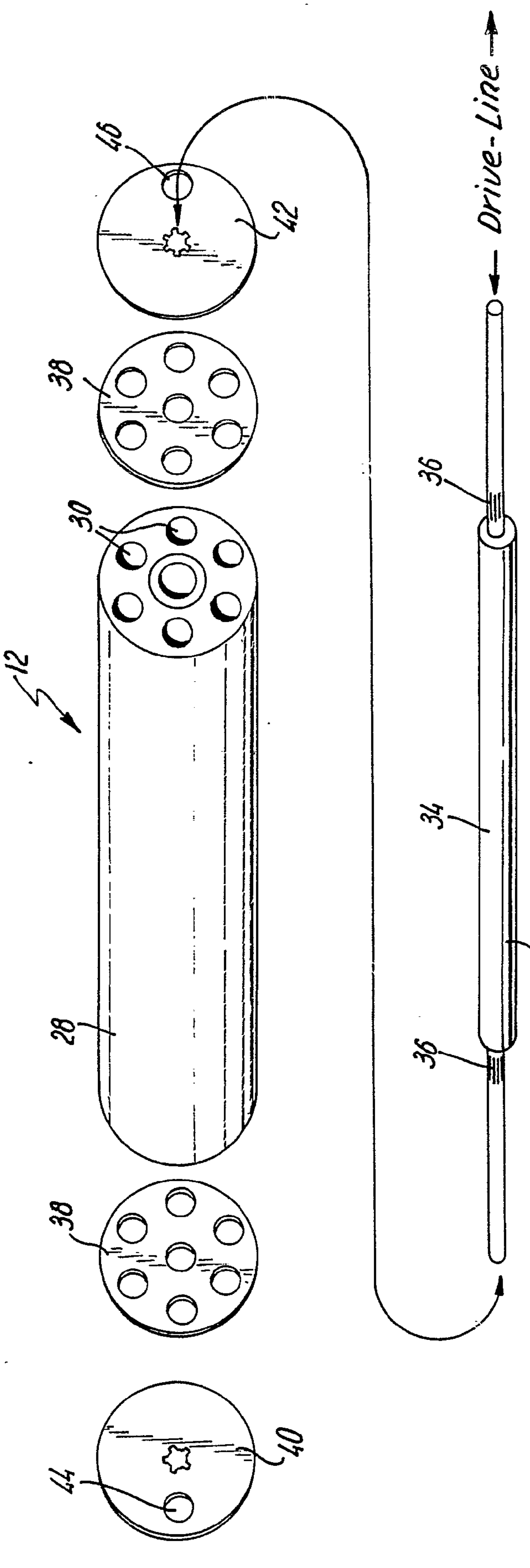

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number

EP 89 30 2703

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X Y	FR-A-2 445 887 (COMPAGNIE FRANCAISE DES PETROLES) * Page 2, line 35 - page 4, line 2 *	1-7 8,9	E 21 B 21/00 E 21 B 7/18 E 21 B 4/02 F 04 C 5/00
Y	US-A-4 391 572 (H.S. LEW) * Abstract *	8	
Y	EP-A-0 204 474 (THE ANALYSTS INT.) * Whole document *	9	
X	FR-A-1 271 127 (STE EUROPEENNE DE TURBOFORAGE) * Abstract *	1-7	
X	US-A-3 897 836 (J.M. HALL et al.) * Column 2, line 32 - column 3, line 20 *	1,4-7	
X	US-A-4 047 581 (J.W. ERICKSON) * Whole document *	1-7	**TECHNICAL FIELDS SEARCHED (Int. Cl.4)**
A	GB-A-2 102 073 (E. COSTARELLI) * Abstract *	8	E 21 B F 04 C
A	US-A-3 951 576 (A.A. LOFQUIST Jr.) * Abstract *	8	
A	US-A-2 946 291 (A. ROEBIG) * Whole document *	8	
A	US-A-4 187 061 (R. JÜRGENS) * Abstract *	8	
A	GB-A-2 190 411 (SHELL) * Whole document *	9	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	04-07-1989	SOGNO M.G.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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